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Adaptive method of encoding and decoding
a series of pictures by transformation,
and devices for implementing this method

5   The invention relates to an adaptive method of
encoding and decoding a series of pictures by trans-
formation, and devices for implementing this method.
The object of such a method is to reduce the quantity
of information to be transmitted, or to be stored,
10 when pictures have been digitized. It is applicable,
for example, to digital video transmission systems or
to digital video recorders.
It is known to encode a digitized picture by using a
two-dimensional transformation of the cosine or Fourier,
15 or Hadamard, or Haar, or Karhunen-Loeve type. Such an
encoding consists in: dividing each picture into blocks
of picture elements, each picture element being rep-
resented by a digital value which is the value of its
brightness or of a colour difference: applying the trans-
20 formation to each block in order to obtain a matrix of
values called the transformation coefficients of the
block; and in transmitting these transformation coef-
ficients in an encoded form, for example using a Huffmann
code. The decoding then consists in: decoding the
25 Huffmann code words in order to obtain the transformation
coefficients; then in restoring the digital values
representing each picture element by applying, to the
transformation coefficients corresponding to a block of
picture elements, the two-dimensional transformation
30 which is the inverse of that used for the encoding. The
transformations used in practice are transformations for
which there exists fast algorithms, for example the co-
sine transformation.
The French Patent Application 2,575,351 describes an
35 adaptive method of encoding and decoding consisting in:
     -   dividing each picture into blocks of picture
elements;

- applying the cosine transformation to each block, the latter being represented by a block of brightness values in order to obtain a block of transformation coefficient;

5 - determining, for each block, if it represents a scene with much movement or little movement;

- transmitting the value of the transformation coefficients of the block if the latter represents a scene with much movement, or transmitting the differences

10 in the value of these coefficients with respect to the coefficients of the similar block in the previous picture, if the block represents a scene with little movement;

- transmitting an information indicating the type

15 of encoding used for each block, these two types of encoding being called respectively intra-picture encoding and inter-picture encoding. The coefficients or differences of coefficients are transmitted in the form of Huffmann code words.

20 According to this known method, the decoding consists, before applying the inverse transformation, in determining a value of the transformation coefficients of each block representing a scene with little movement, by adding the difference in value of each of its coef-

25 ficients respectively to the value of the coefficients of the similar block in the previous picture.

According to this known method, the encoding furthermore consists in applying a weighting to the values of the coefficients or to the values of the differences

30 of coefficients, with a greater weight for the coefficients or the differences of coefficients corresponding to the low spatial frequencies of the picture, with respect to the coefficients or to the differences of the coefficients corresponding to the high spatial frequen-

35 cies of the picture; and in quantifying according to a linear scale the weighted coefficients and differences of coefficients. The quantification step is variable

according to the quantity of information to be trans-
mitted. This is equivalent to multiplying all of the
coefficients or all the differences of transformation
coefficients of a block by a same coefficient called
5 the quantification coefficient which is variable accord-
ing to the quantity of information to be transmitted for
the blocks of picture elements encoded before the block
concerned; and in retaining only the whole part of the
result of the multiplication.
10   The information to be transmitted is stored in a
buffer memory enabling a transmission at a constant rate.
A regulating device supplies a value of the quantifica-
tion coefficient which continuously diminishes while the
buffer memory is filling and which continuously increases
15 while the buffer memory is emptying.
       Naturally, the decoding furthermore consists in
multiplying each transmitted coefficient value or each
transmitted difference of coefficients value, by a
coefficient equal to the inverse of the weighting coef-
20 ficient used for the encoding; and then in multiplying it
by a coefficient equal to the inverse of the quantifica-
tion coefficient used for the encoding.
       When a series of pictures represents a scene
containing much movement, the quantity of information to
25 be transmitted is high, and consequently the quantifica-
tion coefficient is small in order to reduce the
amplitude of the values of the transformation coeffic-
ients or differences of transformation coefficients to be
transmitted. Furthermore, the weighting coefficients
30 give greater weight to the transformation coefficients
corresponding to the low spatial frequencies of the
picture in order to transmit the essential information of
the picture while sacrificing less essential information
which corresponds to the high spatial frequencies of the
35 picture.
       When the series of pictures represents a scene with
little movement or a static scene, the encoding of

each block is of the inter-picture type in order to ex-
ploit the correlation existing between these successive
pictures. From one picture to the next, the values of the
differences of transformation coefficients of similar
5   blocks have a decreasing amplitude and the quantity of
information to be transmitted tends to reduce. The
regulation then reacts by increasing the quantification
coefficient. On the other hand, the information remain-
ing to be transmitted no longer relates to the low
10   spatial frequencies of the picture as it has been
favoured by the weighting and has therefore been trans-
mitted. The information remaining to be transmitted
relates only to the high spatial frequencies of the
picture and the latter are then transmitted with a large
15   amount of information. After a time interval corres-
ponding to several pictures, the totality of the
information representing a static scene is then trans-
mitted and enables the reconstruction of the scene with
very good fidelity.
20   For the encoding and decoding of colour television
pictures, the previously mentioned document suggests
processing in parallel three series of digital values
corresponding to a brightness signal and to two colour
difference signals respectively.
25   This known method has two disadvantages: the fact
of the parallel processing of these three series of
digital values leads to the use of three buffer memories
which must restore the encoded information with data
rates having constant ratios because the transmission
30   channel has a constant data rate. Now, the information
data rates corresponding to a brightness signal and to
two colour difference signals have extremely variable
ratios because the saturation of the colours is very
variable and can even be zero in the case of pictures
35   containing only whites, greys and blacks. The fact of
imposing a constant ratio between these three information
data rates leads in practice to uselessly increasing the

quantity of information transmitted, or in sacrificing a
portion of the information corresponding to colour
differences, which is harmful to the fidelity of the
reproduction.

5   Another disadvantage results from the regulation
used in this method. When, in a same picture, there is a
succession of blocks encoded by an inter-picture en-
coding, the quantity of information to be transmitted
being small, the regulation reacts by increasing the
10   quantification coefficient and tends to maintain a fil-
ling of the buffer memory. If an isolated block, or
several blocks are to then be encoded by an intra-picture
encoding, because they correspond to a limited area which
is in motion, it is suddenly necessary to transmit large
15   amounts of information. The buffer memory being main-
tained practically full, the regulation can only react by
sacrificing a large portion of the information to be
transmitted, i.e. by suddenly reducing the quantification
coefficient when the buffer memory approaches saturation.
20   In such a case, the blocks of picture elements encoded by
the inter-picture encoding are restored with excellent
fidelity while the adjacent blocks, encoded by an intra-
picture encoding are restored with mediocre fidelity.
The difference in quality is then very noticeable because
25   these two types of blocks are adjacent in the same
picture.

       The purpose of the invention is to overcome these
two disadvantages of the known method. The object of the
invention is an adaptive method of encoding consisting in
30   particular in storing in a same buffer memory the infor-
mation to be transmitted corresponding to the values of
brightness and to the values of the two colour difference
signals, and consisting in using weighting coefficients
and identical quantification coefficients, except for the
35   application of a constant, for the transformation coef-
ficients or the differences of transformation coef-
ficients corresponding to these three types of signals.

According to another feature, the method according to the invention consists in using weighting coefficients which, in addition to giving a greater weight to information corresponding to the low spatial frequencies of

5 the picture, are also variable according to the quantity of information to be transmitted, in order to further reduce the weight given to the information corresponding to the high spatial frequencies of the picture when the filling of the buffer memory increases and approaches the

10 maximum.

According to another feature of the method according to the invention, the quantification coefficient is variable as a function of the filling rate of the buffer memory, but with a discontinuity corresponding to a fixed

15 filling threshold, in order to be constant below this filling threshold and in order to increase when the filling rises above this threshold.

According to the invention, an adaptive method of encoding and decoding of a series of pictures by trans-

20 formation, the encoding consisting in:

 - dividing each picture into blocks of picture elements, each block being represented by a block of brightness values, a block of blue colour difference values and a block of red colour difference values;

25 - applying a two-dimensional transformation to each block of values in order to obtain a block of trans- formation coefficients of the block of values concerned;

 - transmitting, for each block of values, either the value of transformation coefficients of the block, or the

30 difference in value of these transformation coefficients, with respect to the value of the transformation coef- ficients of a similar block in the picture preceding the picture being encoded, in order to minimize the quantity of information to be transmitted for the block in ques-

35 tion, the encoding being called intra-picture or inter- picture respectively;

furthermore consisting in multiplying the

transformation coefficients and the differences of
transformation coefficients, before they are trans-
mitted, by a coefficient called the weighting coef-
ficient, favouring the low spatial frequencies of
5 the pictures; and also in multiplying them by a coef-
ficient called the quantification coefficient which
is variable as a function of the quantity of informa-
tion to be transmitted;
     the decoding consisting for each block in:
10 - multiplying   each transmitted value of transfor-
mation coefficient or each transmitted value of trans-
formation coefficient difference, by a coefficient
equal to the inverse of the weighting coefficient used
for the encoding and by a coefficient equal to the in-
15 verse of the quantification coefficient used for the
encoding;
     -   adding, to the value of each difference of
transformation coefficients, the value of a trans-
formation coefficient, similar to the coefficient in
20 question in a similar block to the block in question
and belonging to the picture preceding the picture
being decoded;
     - applying to each transformation coefficient a
transformation which is the inverse of the transformation
25 applied for the encoding, in order to obtain a block of
values representing a portion of the decoded picture;
     is characterized in that it furthermore consists in
regulating the data rate of the transmitted information,
in storing in a same buffer memory, the information to
30 be transmitted corresponding to the 3 types of blocks
of values, and in multiplying the transformation coef-
30 ficients and the differences of transformation coef-
ficients of the 3 types of blocks by a same variable
weighting coefficient and by a same variable quantifi-
35 cation coefficient, except for the application of a
constant multiplication factor.
     The invention will be better understood and other

characteristics will appear with the help of the fol-
lowing description and of the accompanying figures in
which:

    -   Figure 1 shows the order of scanning the
5   transformation coefficients or the differences of trans-
formation coefficients of a block of picture elements, in
one example of implementation of the method according to
the invention;

    -   Figure 2 shows a graph illustrating a weighting
10 performed in this example of implementation;

    -   Figure 3 shows a graph illustrating a quantifica-
tion performed in this example of implementation;

    -   Figures 4 to 6 illustrate the regulation of the
data rate of the transmitted information in this example
15 of implementation;

    -   Figures 7 and 8 illustrate the implementation of
a variant of the method according to the invention;

    -   Figure 9 shows the synchronization signals of an
encoder and a decoder, in an example of implementation of
20 the method according to the invention;

    -   Figures 10 and 11 show the block diagram of an
embodiment of an encoding device for the implementation
of the method according to the invention;

    -   Figures 12 and 13 show the block diagram of an
25 embodiment of a decoding device for the implementation of
the method according to the invention.

    In one example of implementation, the series of
pictures is constituted by a series of colour television
frames, sampled and digitized. Each picture element is
30 represented by a brightness value, a red colour dif-
ference value and a blue colour difference value, each of
these values having eight bits. The brightness is
sampled at a frequency of 10.125 MHz while each of the
colour difference signals is sampled at a frequency of
35 5.0625 MHz. The data rate of the encoded information is
constant and in the order to 10 Mbits per second.

    Each television picture to be encoded is constituted

by two interlaced frames analysed in a conventional
way by a television camera. Each frame is encoded
separately.

5   In this example of implementation the transforma-
tion used is the cosine transformation. It is applied
to blocks of 16 x 16 brightness values, blocks of 16 x 8
red colour difference values, and blocks of 16 x 8 blue
colour difference values. Any other known two-dimen-
10   sional transformation can be used for the implementation
of the method according to the invention. The transfor-
mation is applied in parallel to each of these three
types of block. For each block of values it supplies a
matrix of values called transformation coefficients of
the block of values concerned. The block of transfor-
15   mation coefficients has dimensions identical to those
of the block to be transformed. The transformation
coefficients have real values.

The transformation coefficients of the brightness
values $f(i,j)$ are computed according to the formula:
20

$$F(u,v) = \sum_{i=0}^{15} \sum_{j=0}^{15} f(i,j).c(u).c(v).\cos\frac{(2i+1).u.\pi}{32}.\cos\frac{2(j+1).v.\pi}{32} \quad (1)$$

25   where $c(u) = 1/\sqrt{2}$ if $u = 0$
      $c(u) = 1$ if $u \neq 0$

The transformation coefficients of the colour diffe-
30   rence values $f'(i,j)$ are computed according to the formula:

$$F'(u,v) = \sum_{i=0}^{15} \sum_{j=0}^{7} f'(i,j).c(u).c(v).\cos\frac{(2i+1).u.\pi}{32}.\cos\frac{(2j+1).v.\pi}{16} \quad (2)$$

35

i and j are respectively the line index and the
column index in the block of values to be encoded; u and

v are respectively the line and column indices of the
transformation coefficients in the block of these coef-
ficients. The transformation coefficient situated in the
first column and on the first line is equal to twice the
average value of the coefficients of a block of trans-
formation coefficients. It has a value which is always
positive. This value must be encoded with the greatest
possible accuracy since the slightest error in this
transformation coefficient results in a very visible
difference between a block of picture elements and the
adjacent blocks.

The other coefficients of a transformation block
correspond to spatial frequencies of the picture which
are increasing as u and v increase. For the highest
values of u and v, the transformation coefficients are
generally zero. In the series, the coefficients of a
block of transformation coefficients are considered
according to a scanning order which is graphically
represented in Figure 1 and which corresponds to increas-
ing values of the sum $u^2 + v^2$. The scanning path of
the transformation coefficients is chosen in such a way
as to optimize the compression ratio for the type of
picture which is to be encoded, according to their statis-
tical characteristics.

The implementation of the method according to the
invention then consists in performing, in parallel, an
encoding called the inter-picture encoding and an en-
coding called the intra-picture encoding for each type
of value to be encoded: brightness value, blue colour
difference value and red colour difference value. The
inter-picture encoding consists in computing the dif-
ference in value between the transformation coefficients
of a block of picture elements in question, respectively
with regard to the transformation coefficients of a
similar block to the block in question in the picture
preceding the picture being encoded. The intra-picture
encoding consists in directly using the value of the

transformation coefficients of the block. In both cases,
the method of encoding then consists in applying a weight-
ing, a quantification and then a Huffmann encoding.

     In general, the intra-picture encoding of a block
5   representing a portion of a picture in motion requires a
larger amount of information than the inter-picture
encoding. Conversely, the inter-picture encoding of a
block representing a static portion of picture generally
requires less information than the intra-picture encoding.
10   The choice of the type of encoding is common for all
three types of signal to be encoded. In this example
of implementation, the choice of the type of encoding
consists in precisely determining the quantities of
information respectively necessary in both cases for a
15   same block of digital values to be encoded. Each quan-
tity of information is computed by counting the number
of encoded data bits supplied by the following series
of operations: weighting, quantification, Huffmann
encoding. The method then consists in transmitting the
20   data supplied by the encoding requiring the smallest
amount of information.

     The weighting enables the exploitation of the fact
that a suppression of information encoding certain trans-
formation coefficients of a block of picture elements
25   does not give rise to much degradation in the decoded
picture. The coefficients corresponding to the low
spatial frequencies of the picture are more sensitive
to suppressions of information than the coefficients
corresponding to the high spatial frequencies of the
30   picture. The weighting is such that the coefficients
corresponding to the low spatial frequencies are
favoured. It consists in multiplying the value of the
transformation coefficients or of the differences of the
transformation coefficients of a block by a weighting
35   coefficient which is given, for the brightness, by the
following formula:

$$p^{lum}(u,v) = \exp \left[- \frac{R.u^2+v^2}{Pon^2.Nor} \right] \qquad (3)$$

5   where u and v are respectively the index of the column and of the line of the coefficient or of the difference of coefficients to which the weighting applies; where R is a constant which depends on the size

10   of the block and on the sampling frequency of the picture, its value being 1.4 for a sampling frequency of 10.125 MHz and for a block of size 16 x 16; where Nor is a constant parameter but depending on R which is given by the following formula:

15

$$Nor = \frac{2 \times 16^2}{R \times 16^2 + 16^2} \quad (4)$$

     Nor = 0.42 for a sampling frequency of 10.125 MHz;

20   and where Pon is a variable parameter which defines the severity of the weighting. Its value depends on the filling of the buffer memory storing the encoded information to be transmitted, corresponding to the three types of signal representing the picture elements. This

25   information is the information relating to the blocks preceding the block of picture elements being encoded. The number of bits in question is that obtained after the Huffmann encoding of the non-zero values, the encoding by sequences of zero values, and after insertion of data

30   separating words. The severity of the weighting is an increasing function of the filling of the buffer memory, in order to act against this filling.

     In this example of implementation, the capacity of the buffer memory is 64 kilobits. The value of the

35   parameter Pon, and the weighting ratio obtained, between the high and the low spatial frequencies of the picture are given in the following table:

Filling of buffer memory	Value of the Pon parameter	Value obtained for the weighting ratio high/low frequencies
64 to 48 Kb	18	5
48 to 40 Kb	18.5	4.5
40 to 32 Kb	19	4
32 to 24 Kb	20	3.5
24 to 16 Kb	22	3
16 to 8 Kb	24	2.5
8 to 0 Kb	27	2

The value of the transformation coefficients or of the differences of the transformation coefficients for the colour difference signals, is weighted by a coefficient given by the formula:

$$p^{ch}(u,v) = \exp - \left[\frac{R'.(\frac{u}{2} + 1)^2 + v^2}{Pon^2.Nor'} \right] \qquad (5)$$

where R' is a constant which depends on the size of the block and on the sampling frequency for the colour difference signal and which is equal to 0.7 for blocks of 16 x 8 and for a sampling frequency of 5.0625 MHz; and where Nor' is a constant which is given by the following formula:

$$Nor' = \frac{2 \times 16^2}{R' \times 16^2 + 16^2} \qquad (6)$$

Nor' = 0.59 for a sampling frequency of 5.0625 MHz.

The weighting coefficient $p^{ch}(u, v)$ is also a function of the filling of the buffer memory, by means of the variable Pon, in order to participate in the process

of regulation of the data rate of the transmitted encoded
information. The weighting coefficient is the same for
the data encoded by the inter-picture encoding and for
that encoded by the intra-picture encoding.

5   The method of regulation furthermore consists in
multiplying the value of the transformation coefficient
or of the differences of transformation coefficients of
a block by a quantification coefficient which is a func-
tion of the filling of the buffer memory, the latter
10 containing the encoded data corresponding to the blocks
preceding the block being encoded.

The quantification operation is performed in paral-
lel on the transformation coefficients obtained by the
intra-picture encoding and on the differences of trans-
15 formation coefficients obtained by the inter-picture
encoding, after the weighting operation. For a given
block of picture elements, all of the transformation
coefficients and all of the differences of transforma-
tion coefficients corresponding to the brightness are
20 multiplied by the same quantification coefficient
value. All of the transformation coefficients and all
of the differences of transformation coefficients cor-
responding to the two colour difference signals are
multiplied by a weighting coefficient which has the
25 same value as that corresponding to the brightness,
except for the application of a constant multiplication
factor. This constant is equal to 1.41 in order to
compensate for a constant multiplication factor intro-
duced during the computation of the cosine transforms
30 and which is slightly different for blocks of different
sizes, as is the case for the brightness on the one
hand and for the colour differences on the other hand.

The quantification coefficient is constant for a
filling E_b of the buffer memory, less than a threshold
35 value; it is exponentially decreasing when the filling
E_b is above this threshold value. In this example, in
which the capacity of the buffer memory is equal to 64000

bits, the filling threshold value is taken as equal to
56000 bits. For the brightness, the quantification
coefficient is given by the following formula:

5

$$V^{lum} = \exp(-\frac{E_b - 56000}{Nor}) \quad \text{if } E_b \geqslant 56000 \text{ bits} \tag{7}$$

10    $V^{lum} = 1$ if $E_b < 56000$ bits

     For the colour difference signals, the quantifica-
tion coefficient is given by the following formula:

15

$$V^{chr} = 1,41.\exp(-\frac{E_b - 56000}{Nor'}) \quad \text{if } E_b \geqslant 56000 \text{ bits} \tag{8}$$

20    $V^{chr} = 1,41$ if $E_b < 56000$ bits

     where the constants Nor and Nor' have the previously
defined values.

     The values of the transformation coefficients or of

25 the differences of transformation coefficients are trunc-
ated after the weighting and the quantification in order
to round them to the closest whole value.

     Figure 2 shows the graph of the ratio between the
weighting coefficient applied to the high spatial fre-
quencies and the weighting coefficient applied to the low

30 spatial frequencies of the picture, for the brightness,
as a function of the filling E_b of the buffer memory.
It increases in steps as the filling varies from 0 to 64
Kbits.

35   Figure 3 shows the graph of the quantification
coefficient N^{lum}, corresponding to the brightness, as a
function of the filling E_b. It can clearly be seen on
this graph that the quantification coefficient is

constant for most of the filling values and that it
decreases very rapidly when the filling is close to its
maximum. The relationship between the quantification
coefficient and the filling, in the method according to
5   the invention, is therefore clearly different from those
used conventionally and which vary continuously. A
conventional quantification coefficient does not include
such a horizontal level but decreases regularly as a
function of the filling.

10   Figures 4, 5 and 6 illustrate the regulation pro-
cess, in the case in which three successive pictures
represent a static scene. Each of these figures shows a
graph in which the quantity of information actually
transmitted is plotted vertically and in which the rank
15 of the transformation coefficients or of the differences
of transformation coefficients of each of these pictures
is plotted horizontally, this rank being determined on
the scanning path shown in Figure 1. The quantities of
information concerned are those obtained after the weight-
20 ing, the quantification and the Huffmann encoding.

However, the quantity of information corresponding
to the first transformation coefficient, i.e. having 0
as a line index and as a column index, is not shown in
Figures 4 to 6 as it is not subject to the data rate
25 regulation. The first coefficient is not weighted and is
not standardized in order to avoid showing visible dis-
continuities between the blocks on the restored picture.
Figures 4 to 6 therefore show the quantity of information
corresponding only to the other transformation coef-
30 ficients or differences of transformation coefficients.

The first picture of these three successive pictures
is assumed to be different from the pictures having pos-
sibly preceded it. The transformation coefficients of
this first picture are therefore all encoded by an intra-
35 picture encoding necessitating a large amount of infor-
mation, which is particularly distributed over the
transformation coefficients having a low rank. In

addition, the weighting has the effect of also favouring
the coefficients of low rank. And, finally, certain
coefficients of high rank are rounded to zero during the
operation consisting in rounding to the closest whole
5   value. Everything happens as if there were a threshold
at +0.5 and -0.5. For all of these reasons, in Figure 4,
the coefficients of high rank are not transmitted by any
quantity of information. In particular, many coef-
ficients of high rank are rounded to the zero value
10   because they are less than 0.5 in absolute value. The
number of coefficients or differences of coefficients
rounded to zero increases when there is a reduction in
the quantification coefficient resulting from a large
amount of filling of the buffer memory. The threshold
15   effect combined with the quantification therefore tends
also to suppress information corresponding to high
spatial frequencies.

Figure 5 corresponds to a second picture which
immediately follows the first one and which is identical
20   to it. The transformation coefficients of the second
picture are therefore theoretically strictly identical
to those of the first picture. They will be encoded by
an inter-picture encoding in order to exploit the cor-
relation between the first and second pictures. The
25   inter-picture encoding is performed by computing the
difference between the transformation coefficients of
the second picture and the transformation coefficients
of the first picture after having submitted the latter
to an encoding and then to a decoding in order to sub-
30   tract a same value during the encoding step and during
the decoding step.

The weighting and quantification operations sup-
pressinformation and therefore cause encoding errors
which result in a non-zero difference between the trans-
35   formation coefficients before encoding and the transfor-
mation coefficients after encoding followed by decoding.
There are therefore non-zero differences between the

coefficients encoded and then decoded for the first
picture and the coefficients which will be encoded for
the second picture. These differences are in particular
due to the fact that the weighting coefficient and the
5 quantification coefficient vary from one picture to
another.

Figure 5 shows the quantity of information cor-
responding to these differences of coefficients, these
differences having undergone a weighting, a quantifica-
10 tion and a Huffmann encoding. The quantity of infor-
mation constituted by these differences is lower than
the quantity of information corresponding to the values
of the transformation coefficients of the first picture
for several reasons. Firstly, because the differences
15 of coefficients have low values, since the first picture
and the second picture are identical. This quantity of
information corresponds above all to the average frequen-
cies and to the high frequencies, i.e. to the average
ranks and to the high ranks, because the weighting and
20 quantification performed during the encoding of the first
picture have sacrificed the information corresponding to
the average ranks and to the high ranks. This information
will enable the addition of details in the second re-
stored picture. The encoding of all of the blocks of
25 the second picture being an inter-picture encoding,
using the correlation with the first picture, the
quantity of information to be transmitted diminishes
the buffer memory empties in consequence and the regu-
lation process causes an increase in the quantification
30 coefficient and then its maintenance at the constant
value: 1.

The increase in the quantification coefficient
increases the amplitude of the differences of trans-
formation coefficients and therefore tends to increase
35 the quantity of information to be transmitted for the
coefficients of average and high ranks, and therefore
tends to fill the buffer memory. However, the levelling

of the quantification coefficients slows down this tend-
ency. Furthermore, the information to be transmitted
corresponds in particular to the average and high spatial
frequencies since the information corresponding to the
5 low spatial frequencies has been transmitted to a large
degree during the encoding of the first picture. The
weighting acts progressively against the high frequencies
as the buffer memory becomes filled. Therefore the weight-
ing itself also tends to reduce the quantity of information
10 transmitted for the second picture. Finally, this quantity
if distinctly less than that transmitted for the first
picture.

The encoding of a third pictureidentical to the two
previous ones is also an inter-picture encoding and only
15 has to transmit information corresponding to high spatial
frequencies which have not been able to be transmitted
during the encoding of the first and second pictures.
This information will enable the addition of fine details
to the restored third picture. Thus when there is a series
20 of static pictures, the restored pictures rapidly achieve
a very good fidelity.

Figure 6 shows the quantity of information to be
transmitted for the third picture, as a function of the
rank of the coefficients. It should be noted that this
25 quantity of information corresponds in particular to the
very high spatial frequencies and that it is generally
smaller with respect to the quantity of information to be
transmitted for the encoding of the second picture and for
the encoding of the first picture, because the weighting
30 very much acts against the very high frequencies, even
though the buffer memory is beginning to empty. The
severity of the quantification and the weighting is chosen
such that the regulation does not tend to maintain the
filling at a constant level, but tends to reduce the
35 filling during each inter-picture encoding.

In the most general case, each picture comprises
static areas and areas in motion. The blocks located in

the areas in motion require an intra-picture encoding
which tends to saturate the buffer memory. The severity
of the weighting and the quantification is chosen such
that the memory is not saturated by the information cor-
5 responding to these blocks. The weighting is a function
of the filling of the buffer memory in such a way that it
acts to a lesser degree against the coefficients or the
differences of coefficients corresponding to the high
spatial frequencies, as the filling diminishes. But the
10 severity of the weighting remains such that the buffer
memory empties when there is a series of blocks encoded
by the inter-picture encoding, in order to have a
capacity available for the encoding of blocks encoded by
an intra-picture encoding which produces a large amount
15 of information to be transmitted.

Thus when one or more successive blocks have to be
encoded by an intra-picture encoding, the buffer memory
is not close to saturation and consequently the quantifi-
cation coefficient does not have to be suddenly increased
20 in order to avoid an overshooting of the capacity of the
buffer memory when a block to be encoded by the intra-
picture encoding arrives. By avoiding sudden variations
in the quantification coefficient, this regulation process
avoids suddenly degrading the quality of restoration of
25 the picture from one block to another in the same picture.
This makes it possible to avoid a visible contrast in the
quality of restoration, between blocks encoded by inter-
picture encoding and blocks encoded by intra-picture en-
coding, close to each other in the same picture.

30 Since the method according to the invention consists
in multiplying the transformation coefficients or differ-
ences of transformation coefficients corresponding to the
brightness and to the colour difference signals, by the
same weighting coefficient and by the same quantification
35 coefficient, apart from the application of a constant
multiplication factor, these three types of signals are
therefore encoded with the same quality within a same

block, and the information to be transmitted can be
stored in a common buffer memory. This storage in a
common buffer memory enables the transmission of the
encoded information with any ratio between the quanti-
5 ties of information corresponding to the three types
of signals. The absence of an imposed ratio between
the quantities of information transmitted for the
three types of signals enables, with equal fidelity,
an important gain in the compression rate of the
10 pictures.

        In fact, the quantity of information to be trans-
mitted for the two colour difference signals is extremely
variable depending on the scenes represented by the
pictures. When the pictures have colours which are not
15 very saturated, the quantity of information to be trans-
mitted for the colour difference signals is low. In
this case, the common regulation enables the transmission
of a reduced quantity of information for the colour dif-
ference signals, unlike the conventional method of inde-
20 pendent regulation for the three types of signals, which
leads to the use of three independent buffer memories
and imposes a constant ratio between the quantities of
information transmitted for the three types of signals.

        The filling E_b of the buffer memory must be known
25 before starting the encoding of a block in question. It
must take into account the encoded information corre-
sponding to all of the blocks which precede the block
in question. It is computed by adding the quantities
of information to be transmitted for all of the blocks
30 preceding the block in question, and by subtracting
from this sum the quantity of information transmitted,
computed by taking the product of the data rate of the
transmission channel and the duration which has elapsed
between the start of the transmission and the end of
35 the transmission of the information encoding the block
preceding the block in question.

        After the quantification, each value of a

transformation coefficient or difference of transformation
coefficients, with the exception of the first coefficient
in each block, and with the exception of the zero values,
is encoded by a Huffmann code. The transformation coef-
ficients or differences of transformation coefficients of
one block are considered successively in the order of scan-
ning corresponding to increasing $u^2 + v^2$, according to
Figure 1. The coefficients or differences of coefficients
which are zero are encoded by sequences, the lengths of
the sequences being encoded by a Huffmann code. The order
of scanning chosen is such that the series of coefficients
or of differences of coefficients of a block always ends
with a long sequence of zero values. The first coef-
ficient or the first difference of coefficients of each
block, having 0 as a line index and as a column index,
is transmitted without Huffmann encoding.

In order to optimize the reduction of the data rate,
the Huffmann encoding is performed according to 8 dif-
ferent trees;

- A1, for encoding the transformation coefficients
corresponding to the brightness signal, which are pre-
ceded by a sequence of zeroes;

- A2, for encoding the transformation coefficients
corresponding to the brightness signal, which are not
preceded by a sequence of zeroes;

- A3, for encoding the differences of transforma-
tion coefficients corresponding to the brightness signal,
which are preceded by a sequence of zeroes;

- A4, for encoding the differences of transforma-
tion coefficients corresponding to the brightness signal,
which are not preceded by a sequence of zeroes;

- A5, for encoding the transformation coefficients
corresponding to any of the colour difference signals,
which are preceded by a sequence of zeroes;

- A6, for encoding the transformation coefficients
corresponding to any of the colour difference signals,
which are not preceded by a sequence of zeroes;

- A7, for the encoding of the differences of transformation coefficients corresponding to any of the colour difference signals, which are preceded by a sequence of zeroes;

5   - A8, for the encoding of differences of transformation coefficients corresponding to any of the colour difference signals, which are not preceded by a sequence of zeroes.

However, it is possible to use identical encoding
10 trees A5 and A7; and identical encoding trees A4, A6 and A8, at the cost of a certain degradation in the compression rate. It should also be noted that the encoding trees also encode particular events: packing bits and data separator words.

15   The fact of using two different trees for encoding the values of coefficients or of differences of coefficients which are not zero and which are not preceded by a sequence of zeroes and for encoding the coefficients or differences of coefficients which are not zero and which
20 are preceded by a sequence of zeroes, results in a reduction in the quantity of information to be transmitted in the order of 10% with respect to the known methods in which a single encoding tree is used for these two separate cases. The reason for this reduction is as follows:
25 a priori, it would be necessary to have two separate trees, with a prefix to distinguish them from each other, in order to encode on the one hand a sequence of zeroes and, on the other hand, to encode a coefficient or a non-zero coefficient difference. But there are never two
30 consecutive sequences of zeroes, as in this case they would be encoded as a single sequence. Consequently, it is certain that after a sequence of zeroes there is a coefficient or a difference of coefficients which is not zero. It is known information which does not
35 therefore have to be transmitted. The use of the two trees mentioned above enables this redundancy of information to be exploited in order to reduce the

quantity of information to be transmitted.

In this example of implementation, the Huffmann codes used for encoding the coefficients have a dynamic range limited to -63, +63. Those used for encoding
5 the differences of coefficients have a dynamic range limited to -31, +31. In the case of overshoot, at least one overshoot prefix is added. In order to distinguish the 0 modulo +64 and the 0 modulo -64 values, two distinct code words are added. The multiple values of
10 +64 and -64 are respectively denoted 0+ and 0- in the following description and they encoded using several overshoot prefixes. The last sequence of zeroes in each block is not encoded, the encoded data corresponding to each block being separated by an inter-block synchro-
15 nization word. The value of the first coefficient or of the first difference of coefficients in each block is represented in clear by nine bits.

The eight Huffmann trees satisfy the following conditions:
20   - the code words all have a length less than 16 bits;

     - no licit concatenation of code words must make a series of 10 zeroes appear, consequently:

       -- the code words cannot terminate, unless by
25 exception, in more than 5 zeroes;

       -- the word "00000" is reserved for precise uses;

       -- the code words cannot begin with more than 4 zeroes;

     - only the encoding trees corresponding to the
30 colour difference signals include synchronization words.

The encoding tree A1 encodes 195 events. The non-zero coefficients give rise to 129 possible events which are: the values -63, ..., -1, 1, ..., +63; an overshoot prefix relating to the coefficients; a value which is a
35 multiple of +64, which is referenced 0+; a value which is a multiple of -64, which is referenced 0-.

     - The sequences of zeroes give rise to 65 possible

events: the values of length : 1, ..., 63 : an overshoot
prefix relating to the sequences of zeroes; and a zero
value 0_p associated with the sequences of zeroes.

    - A particular event is constituted by a packing.

5   The conditions which this tree A1 must satisfy are
as follows: the event 0+ must be encoded by "00000"; the
code words must end in at least 3 zeroes; and the over-
shoot prefix for the coefficients must end in 1.

    The tree A2 encodes 129 events: the values -63, ...,
10 -1, 1, ..., 63; an overshoot prefix relating to the
coefficients; a value which is a multiple of +64, ref-
erenced 0+; a value which is a multiple of -64, refer-
enced 0-. This tree must satisfy the following condition:
the shortest code word must have a length of two bits and
15 be constituted by "00". There is no prohibited event.

    The tree A3 encodes 195 events and has the following
characteristics:

    - the non-zero coefficients give rise to 129
events: the values -63, ..., -1, 1, ..., 63; an
20 overshoot prefix relating to the coefficients; a value
which is a multiple of +64; and a value of which is a
multiple of -64;

    - the sequences of zeroes give rise to 65 events:
the values 1, ..., 63; an overshoot prefix relating to
25 the sequences of zeroes; a value 0_p relating to the
sequences of zeroes;

    - a particular event is constituted by a packing.

    This tree A3 must satisfy the following conditions:
the value which is a multiple of +64 is encoded by "00000";
30 the code words must not end in more than 4 zeroes; the
length of the code words, for the lengths of sequences of
zeroes, is greater than three bits; and the overshoot
prefix relating to the coefficients must end in a 1.

    The tree A4 must encode 65 events which are: the
35 values of non-zero coefficients: -31, ..., -1, +1, ...,
31; an overshoot prefix relating to coefficients; a value
which is a multiple of +31; a value which is a multiple

of -31. This tree must satisfy the following condition:
the shortest code word must have a length of one bit and
be equal to 0. There is no prohibited event.

The tree A5 encodes 131 events and must have the
following characteristics: 65 events for the
coefficients, constituted by the values -31, ..., -1, +1,
..., 31 ; an overshoot prefix relating to coefficients,
0+, 0-; 65 events for the sequences of zeroes; the values
1, ..., 63, an overshoot prefix associated with the
sequences of zeroes, and the zero length; a particular
event which is constituted by an intra-block synchro-
nization word. This tree must satisfy the following
conditions: the value 0+ must be encoded by 00000; the
sequences of zeroes cannot end in more than 4 zeroes;
the length of the sequences of zeroes must be greater than
3; and the code of the overshoot prefix relating to the
coefficients must end in 1.

A particular event is constituted by an intra-block
synchronization word.

The tree A6 encodes 65 events and it is identical to
the tree A4.

The tree A7 encodes 131 events and it is identical
to the tree A5.

The tree A8 encodes 65 events and it is identical
to the tree A5.

An optional refinement of the method according to
the invention consists in making the weighting coef-
ficient and the quantification coefficient functions
of a parameter called the category of the block of
elements being encoded. This parameter represents the
difficulty of restoration of this block of picture
elements. In fact, experience shows that the worst
restored blocks are characterized by the fact that they
contain at least one relatively uniform dark area
extending over at least one block of picture elements
adjacent to the block in question, the boundary between
the two blocks passing through the dark area over a

relatively long length. In such a case the dark area is
encoded differently on either side of the boundary, which
makes the division of the picture into blocks visible,
particularly because the granular noise is not restored in
5   the same way and is visible particularly in a dark area.

In one example of implementation, the method con-
sists in classifying the blocks of picture elements into
eight categories numbered from 1 to 8 according to the
increasing difficulty in restoring them without making
10 the boundaries between the blocks appear. It consists in
sub-dividing each block of 16x16 elements into blocks of
4x4 elements, then in computing the average value of the
brightness in each of the sub-blocks of 4x4 elements. In
practice, only the sub-blocks located at the periphery of
15 a block are considered.

Figure 7 shows an example of a block, with the twelve
sub-blocks for which an average value of the brightness is
computed. The latter are cross-hatched. The method then
consists in computing an average value of brightness in
20 areas of elongated shape located at the periphery of the
blocks of picture elements and covering two adjacent sub-
blocks. These areas partially overlap. In Figure 7 the sub-
blocks are numbered in the clockwise direction starting from
the one located in the upper left-hand corner. In Figure 8
25 the areas are numbered in the clock-wise direction starting
from the one located in the top left corner. For example
the area $N^\circ 1$ covers the sub-block $N^\circ 1$ and sub-block $N^\circ 2$.
The area $N^\circ 2$ covers the sub-block $N^\circ 2$ and the sub-block
$N^\circ 3$. The average brightness value in an area is equal to
30 the half-sum of the average brightness values of the two
sub-blocks enclosed by this area. This average brightness
value is computed according to the following formula:
L(area N° i) = 1/2 (L(block N° i)

+ L(block $N^\circ (i+1)$))   (9)

35   For i = 1 to 12 ; and where L(block N° i) and
L(block $N^\circ i(+1)$) respectively represent the average

brightness value in block N°i and the average
brightness value in block N°i+1.

The method then consists in determining the area
having the smallest average brightness value. This
minimum brightness value is referenced Lmin and deter-
mines the difficulty of encoding the block in question.
The method then consists in classifying the block in
question into a category of difficulty from among eight
categories, by comparing the minimum brightness value
with seven threshold values and consists in determining
a weighting coefficient and a quantification coefficient
depending on the category of difficulty determined for
the block in question.

The severity of the weighting and of the quant-
ification coefficient is reduced as the difficulty of
encoding a block becomes greater, i.e. as the determined
minimum brightness becomes lower. The distribution of
the blocks into eight categories of difficulty enables a
progressiveness in the reduction of severity in the
weighting and quantification when the encoding difficulty
increases.

Another optional characteristic of the method accord-
ing to the invention consists in the protection against
the propagation of errors, a propagation associated with
the differential inter-picture encoding method. If simi-
lar blocks in a series of pictures, i.e. having the same
position in each of the pictures in the series, are en-
coded using inter-picture encoding, an error in the
first block is repeated in all of the following similar
blocks. When such an error can be detected, it is pos-
sible to replace all of the incorrect block by the similar
block of picture elements in the picture preceding the one
containing the incorrect block. As the pictures are, in
this example, constituted of two separately encoded frames,
the similar block is a block of elements of the frame pre-
ceding the frame in question and having the same parity.
However, this correction method does not restore a perfect

picture and, consequently, it is therefore necessary
to limit the propagation of errors by imposing an
intra-picture encoding for each block having a given
position, with a fixed maximum interval corresponding,
5 for example, to 30 pictures. If the intra-picture
encoding is imposed at random or periodic times, the
cost in data rate is significantly increased.

The method according to the invention enables the
limitation of the propagation of errors with a slight
10 increase in the information data rate. It comprises a
first criterion consisting in imposing the intra-picture
encoding when, for a given block, the relative difference
of the cost of inter-picture encoding and the cost of
intra-picture encoding is less than a first threshold
15 value, or when the given block has not been encoded by an
intra-picture encoding for a number of pictures $N(i,j)$
greater than a second fixed threshold value; (i,j) being
coordinates marking the position of the block in a
picture. The first threshold value can be a function
20 $f(N(i,j))$ of the number of pictures since the given block
was encoded by an intra-picture encoding. It is an
increasing function in such a way that it causes an
intra-picture encoding at the end of a certain time, even
if the relative cost difference remains constant.
25 The relative difference between encoding costs is
computed by taking the difference between the number of
bits necessary for the encoding of the block using an
intra-picture encoding and the number of bits necessary
for encoding the block using an inter-picture encoding,
30 and in dividing this difference by the number of bits
necessary for encoding the block using an inter-picture
encoding. The function $f(N(i,j))$ can be a function of
the form $A.N^2(i,j)$ or $A.N^3(i,j)$, in which A is a con-
stant chosen such that the forcing takes place at the
35 latest after 50 frames encoded by inter-picture encoding.
In practice, it is necessary to provide a second cri-
terion enabling the number of pictures during which a

given block is encoded by inter-picture encoding to be
limited in a definite way. This second criterion con-
sists in comparing the number of pictures during which
the given block has been encoded by inter-picture encod-
5   ing with a second threshold value No fixed for example
at 50, which corresponds to 50 frames and therefore to
a duration of 1 second in a European television standard.
     In certain cases, these criteria can lead to a large
number of intra-picture encoding forcings in a same pic-
10   ture. In order to avoid a sudden increase in the quantity
of information to be transmitted, it is necessary to stag-
ger in time the intra-picture encoding forcing operations.
For this purpose, the method furthermore consists in
imposing an intra-picture encoding only for successive
15   blocks separated by an interval greater than a third fixed
threshold value. For example, it can consists in only
allowing the forcing for blocks whose number, in the frame
in question, is equal to N_1 modulo 4, N_1, being a whole
value varying from 0 to 3 and changing at each frame. In
20   this example, any block is encoded by an intra-picture
encoding with an interval at most equal to N_0 + 4 frames.
     The encoding method according to the invention fur-
thermore consists in transmitting with the encoded data
synchronization information enabling the sampling frequency
25   of the pictures to be recovered after transmission over an
asynchronous channel; and furthermore consists in transmit-
ting separators enabling the nature of the various encoded
data which are transmitted in series over the transmission
channel to be recovered.
30   In order to recover the frequency called the video
frequency of the picture sampling, two types of synchro-
nization patterns are transmitted independently from
the encoded data and their separators, while freezing
the transmission of these encoded data. A picture
35   synchronization pattern is transmitted at a frequency
of 25 Hz, before the encoded data of each even frame;
and a line synchronization pattern is transmitted at

the frequency of 15625 Hz, in order to slave a clock
to the picture elements sampling frequency. These two
types of synchronization pattern do not have a fixed
position with respect to the encoded data and are not
5 shown in Figure 9.

These two types of synchronization pattern do not
have to be such that they cannot be imitated by con-
catenations of data, because these patterns are sepa-
rated by a given number of bits, determined to the
10 nearest 1 bit. A learning process, consisting in check-
ing the presence of successive patterns at times provided
for this, enables them to be distinguished from data.

The encoded data separators are shown in Figure 9.
The encoded data corresponding to two frames are preceded
15 by a picture separator which is repeated 8 times in
this example. Each picture separator comprises a 16-bit
prefix comprising 15 zeroes and 1 one; and includes a 3-
bit binary word giving the rank of the separator in the
repetition. In practice, the number of repetitions is
20 chosen as a function of the error rate in the transmis-
sion channel. The prefix is a binary word which cannot
be imitated by a licit concatenation of Huffmann code
words and of inter-block separator words. The repetition
of the picture separators enables them to be protected
25 from isolated errors and small packets of errors. The
detection of a picture separator is only validated if
it is made several times and the exact position of the
picture separators is known by means of the 3 bits
encoding the rank of each picture separator.

30   The encoded data corresponding to block N° 1 are
transmitted after the picture separator repeated 8
times. Then an inter-block separator is transmitted and
precedes the encoded data for block N°2. The inter-block
separator comprises an 11-bit radical constituted of 10
35 zeroes and 1 one; a two-bit binary word representing the
rank of the block, modulo 4; and a two-bit binary word
representing the sum modulo 4 of the rank of the block

and the number of events encoded in the block following
the inter-block separator. The radical thus constituted
can be imitated by a licit concatenation of code words
belonging to the eight Huffmann encoding trees. For this
5   purpose the encoding trees comprise code words beginning
with at most four 0 and ending in at most five 0. A
code word including only 0 is prohibited since, if it
were repeated, there would be imitation of the inter-
block separator.

10   The lower section of Figure 9 shows the format of
the encoded data for a block. It comprises: a three-bit
binary word representing the category of the block; a bit
indicating the type of encoding, inter-picture or intra-
picture, encoded data of the red colour difference signal;
15   then these data, with a number of variable bits; then an
intra-block separator constituted by a Huffmann code word;
then one bit called the inter-intra bit, indicating the
type of encoding of the encoded data for the blue colour
difference signal; then an intra-block separator, consti-
20   tuted by a Huffmann code word; then a bit indicating
the type of encoding for the brightness signal encoded
data; then the encoded data of the brightness signal.

It should be noted that the picture separators
introduce a negligible redundancy considering their
25   rarity. The intra-block separators are essential since
the last sequence of zeroes of each block is not encoded.
They are not protected and do not therefore introduce
redundancy. On the other hand, there is a redundancy in
the inter-block separators. According to the prior art,
30   the inter-block separators belonged to the inter-picture
and intra-picture encoding trees of the brightness signal
and had a length of 5 bits. The one used in this example
of implementation has a length of 15 bits, giving a re-
dundancy of 10 bits. Furthermore, the Huffmann encoding
35   Furthermore, the Huffmann encoding trees of the colour
difference signals include a reserved word formed of five
consecutive 0 for encoding the value 0+, which increases

the average length of the Huffmann codes with respect to
those used in the prior art. Redundancy of information
in the inter-block separators is estimated as equal to
at least 1% of the total transmitted information. This
5   redundancy is low but enables the protection against
errors of inter-block separators to be considerably
improved.

A good detection of inter-block separators is
essential as the loss of a single bit of the encoded
10   data causes a total loss of synchronization of the
decoding with respect to the encoding and therefore
causes the loss of a complete picture.

In the case in which an inter-block separator is
incorrect, it is possible to resynchronize the decoding
15   with the encoding by means of the binary word
representing the rank of the block, modulo 4.

There are at least four possibilities of detecting
an error in a block, at inter-block separator level:
-   by detecting an inter-block separator before
20   having detected the two intra-block separators contained
in any normal block;
-   by detecting an inter-block separator whose begin-
ning does not correspond with the end of the data of the
preceding block, the end of these data being provided by
25   means of the two-bit binary word representing the rank of
the block plus the number of events modulo 4;
-   by detecting a block rank, modulo 4, not equal
to the rank of the previous block incremented by 1;
-   by detecting a sum of a block rank and of a
30   number of events, modulo 4, which is not equal to the sum
of the rank of the block and of the the number of events
received.

The reception of a block is only validated if none
of these conditions occurs. Experience shows that the
35   use of the rank of the block, modulo 4, and of the sum of
the rank of the block and of the number of events, modulo
4, which are transmitted in the inter-block separators,

enables a large majority of errors affecting the blocks
to be detected.

When a block is detected as being incorrect, the
method then consists in masking it by replacing it with
5   the similar block in the frame which immediately precedes
the frame being decoded. It should be noted that an
isolated error in an inter-block separator gives rise to
the masking of the block which precedes it and the block
which follows it, since the end of the first and the
10   start of the second are not correctly identifiable.

The most annoying type of error is constituted by
packets of errors affecting at least four consecutive
blocks, because in this case is it not possible to
resynchronize the decoding with the encoding since the
15   rank of the block is transmitted modulo 4. All of the
following blocks, in the same picture, are shifted. The
synchronization is only regained at the start of the next
picture. Furthermore, the error propagates over the
following images in the blocks encoded by inter-image
20   encoding. It is possible to increase resistance to
errors of the inter-block separators by increasing the
modulo of the word representing the rank of the block and
of the word representing the sum of the rank of the block
and the number of events.

25   Figure 10 shows the block diagram of an embodiment
of an encoding device for the implementation of the
method according to the invention. This example com-
prises: an input terminal 1; a frame memory 2; a first
and a second block memory 3 and 4; a device 5 for the
30   classification of the blocks; a brightness encoding
device 6; a colour difference encoding device 7; a device
8 for computing the quantification coefficient and the
weighting coefficient; a memory 9; a Huffmann encoder and
separator generator device 10; a sequencer 11; a shift
35   register 12; a picture synchronization and line synchro-
nization generator 13; a device 14 for computing the
filling of the buffer memory, constituted by the memory

9, the device 10 and the register 12; a device 15 for
computing the quantity of transmitted information; and
an output terminal 19 connected to an asynchronous trans-
mission channel having a constant data rate of 10 Mb per
5   second.

The input terminal 1 receives in parallel a bright-
ness value Y, a red colour difference value DR, and a
blue colour difference value DB in the form of a triplet
of binary words. Each triplet represents an element of
10 a picture. The series of pictures concerned is a conven-
tional series of television pictures in which each pic-
ture is constituted from two interlaced frames but
these two frames are independently encoded. The bright-
ness signal is sampled at the frequency of 10.125 MHz
15 and each of the colour difference signals is sampled at
a frequency of 5.06 MHz. The encoding devices 6 and 7
operate in parallel. While the device 6 encodes two
brightness values, the device 7 encodes a red colour
difference value and a blue colour difference value.
20   A data input of the frame memory 2 is connected to
the input terminal 1. Read and write control inputs of
this memory 2 are connected to the outputs of the se-
quencer 11 by links which are not shown. The sequencer
11 controls the storage of the values Y, DR, DB, as they
25 become available. A data output of the memory 2 is
connected to data inputs of the block memories 3 and 4.
Control inputs of the memories 3 and 4 are connected to
outputs of the sequencer 11 by links which are not shown.
The sequencer 11 controls the reading from the memory 2
30 and the writing into the memory 3 of 16x16 brightness
values representative of a block of 16x16 picture
elements. It simultaneously controls the reading from
the memory 2 and the writing into the memory 4 of 8x16
red colour difference values and of 8x16 blue colour
35 difference values representative of the same block of
picture elements.

A data output of the block memory 3 is connected to

an input terminal 20 of the device 6 and to an input of
the classification device 5. A data output of the block
memory 4 is connected to an input of the device 7.
Another input of the device 7 and an input terminal 21 of
5   the device 6 are connected to an output of the device 8.
The device 8 supplies the value of a quantification coef-
ficient and of a weighting coefficient, calculated in
order to regulate the data rate of the encoded inform-
ation transmitted on the transmission channel. The
10   device 8 has a first input connected to an output of the
classification device 5, and a second input connected to
an output of the computing device 14. The device 14 has
a first input connected to an output of the device 15, a
second input connected to an output terminal 22 of the
15   device 6 and a third input to a first output of the
device 7.

The memory 9 has: a first data input connected to an
output terminal 23 of the device 6 and to a second output
of the device 7; a second data input connected to an
20   output terminal 24 of the device 6 and to a third output
of the device 7; and a third data input connected to an
output of the sequencer 11.

The function of the memory 9 is to store the values
of cosine transformation coefficients or of cosine trans-
25   formation coefficient differences, or the lengths of
sequences of zeroes, representing the brightness values
or the colour difference values in order to enable a
regulation of the data rate of the encoded information
sent in the channel. The data received by the first data
30   input of the memory 9 are transformation coefficient
values or transformation coefficient difference values or
lengths of sequences of zeroes. The data received by the
second data input of the memory 9 are indicators corres-
ponding to the data applied to the first data input, in
35   order to indicate the type of encoding, inter- or intra-
picture, and the type of data: data corresponding to
brightness values or to a red colour difference or to a

blue colour difference, and indicating their coef-
ficients or differences of coefficients which are
not zero on the one hand, and the lengths of se-
quences of zeroes on the other hand.

5   The data received by the third data input of the
memory 9 also corresponds to the data received by the
first input and indicate the start of a block or, within
a block, the start of the brightness data, or the start
of the red colour difference data or the start of the

10   blue colour difference data. These two indicators are
stored in the memory 9 at the same time as a datum rep-
resenting the brightness or a colour difference and con-
stitute an instruction for controlling the device 10,
a Huffmann encoder and separator generator, in order

15   to encode the data according to eight distinct Huffmann
trees, and in order to supply the inter-block separators,
the intra-block separators and the inter-picture sepa-
rators. The memory 9 has two outputs respectively con-
nected to two inputs of the device 10 in order to

20   supply it in parallel with a datum and a corresponding
instruction.

       The memory 9 also has read and write control inputs
respectively connected to outputs of the sequencer 11 by
links which are not shown. The sequencer 11 controls the

25   reading of data and of the corresponding instructions
progressively as the device 10 encodes and transmits
these data on the channel.   The device 10 indicates to
the sequencer 11 its availability by a link which is not
shown.

30   The device 10 has an output connected to a parallel
input of the shift register 12. The register 12 has an
output connected to the output terminal 16 of the en-
coding device and has a control input receiving a clock
signal HC which defines the transmission frequency on

35   the channel. The picture synchronization and line
synchronization generator 13, has an output also con-
nected to the output terminal 14 in order to supply

synchronization patterns at picture frequency and at
line frequency. The generator 13 is controlled by the
sequencer 11 by means of a link which is not shown.
The transmission of the synchronization patterns is
5   performed completely independently from the transmis-
sion of the encoded data and their separators while
periodically freezing the transmission of these encoded
data in order to transmit the synchronization patterns.
These patterns will enable, after the decoding, the
10   recovery of the picture and line frequencies which are
asynchronous with respect to the channel frequency.
     The device 10 is essentially constituted by a
sequencer and by read only memories. The read only
memories enable the performance of a transcoding from
15   data supplied by the memory 9; this transcoding is a
function of the type of data and the type of data is
indicated by the instruction accompanying them. The
sequencer is controlled by these instructions to select
a read only memory corresponding to a Huffmann code
20   appropriate to the data to be transcoded. The sequencer
also supplies the binary words constituting the inter-
block separators, the intra-block separators and the
picture separators. This sequencer comprises counters
for determining the rank of each picture separator, the
25   rank of each block, modulo 4, and the sum of the rank of
each block and of the number of events encoded in this
block, modulo 4, in order to include these values in the
separators, according to the previously described
method.
30   The sequencer 11 supplies clock signals to all of
the components of this encoding device and it supplies in
particular control signals to the devices 6 and 7 with a
period corresponding to the processing of a block of 16x16
picture elements. It should be noted that the values
35   representative of the picture elements are stored in the
frame memory 2 with stop time intervals corresponding to
the line suppression and to the frame suppression.

But these representative values are re-read from the
memory 2 at a slightly slower rate, such that the
reading is performed at a regular frequency without
taking account of the line suppression and frame
5 suppression time intervals.

An output of the device 10 is connected to a
parallel input of the shift register 12 to supply it
with a binary word corresponding to an encoded datum or
to a separator. The shift register 12 transmits the bits
10 of this binary word successively to the output terminal
19 under the effect of the clock HC which corresponds to
the transmission frequency on the channel in question.

The device 8 supplies a weighting coefficient which
is the same for the brightness encoding device 6 and for
15 the colour difference encoding device 7; and it supplies
a quantification coefficient which is the same, except
for the application of a multiplication coefficient, for
the devices 6 and 7. These two coefficients therefore
provide a common regulation for the data rate of the
20 information to be transmitted corresponding to the
brightness and for the information to be transmitted
corresponding to the colour differences. The memory 9
stores both of these types of information to be
transmitted together with indicators enabling these
25 different types of information to be identified and
constituting instructions for controlling the device 10.

As the memory 9 is placed upstream of the Huffmann
encoder 10, the regulation of the flow of bits on the
channel consists in fact in acting on the amplitude of
30 the coefficients or coefficient differences, by the
variable weighting and quantification, before encoding
them by means of the Huffmann encoder. A reduction in
the amplitude is represented by a reduction in the
number of bits at the output of the Huffmann encoder.
35 Everything happens as if there were, instead of the
memory 9, the device 10 and the register 12, only a
buffer memory storing the binary data in series and

restoring them in series to the channel. The device 14 in
fact computes, not the filling of the memory 9, but the
filling of this buffer memory. The filling of the buffer
memory is equal to the quantity of binary information, in
5   the form of Huffmann codes, remaining to be transmitted
at the time in question. There is no mathematical
relationship between the filling of the memory 9 and the
filling of the buffer memory. Consequently, the capacity
of the memory 9 is chosen by considering the average
10   length of the Huffmann codes. In this example, the
average length is equal to 2 bits. The memory 9 has a
capacity of 32K words, each word being constituted by a
datum and an instruction, and corresponds to a capacity
of 64K bits for the buffer memory as defined before.
15   The device 15 supplies to the device 14 the value of
the quantity of information transmitted on the channel.
The devices 6 and 7 supply to the device 14 the cost of
encoding each coefficient or difference of coefficients.
The device 14 computes the value of the filling of the
20   buffer memory by accumulating the costs of encoding and
by subtracting the transmitted quantity. Then it sup-
plies the value of the filling to the computing device
8 which determines a quantification coefficient and a
weighting coefficient according to the formulae (3) to
25   (8), by modulating the severity of the quantification and
of the weighting as a function of the category of the
block determined by the device 5.
The counting device 15 determines the number of trans-
mitted bits, from the clock signal HC which indicates to
30   it the frequency of transmission on the channel, which is
known and constant but which is asynchronous with respect
to the sampling frequency of the pictures. The value of
the ratio of weighting of the high frequencies with re-
spect to the low frequencies corresponds to the values
35   shown in Figure 2. The brightness quantification coef-
ficient has a constant value for a buffer memory filling
varying from 0 to 56 Kb and then decreases exponentially

for a filling varying from 56 Kb to 64 Kb.

The device comprises, in series, between its input
and its output: a device 16 for computing the average
brightness in the peripheral areas of each block of
5   picture elements; a device 17 for determining the minimum
brightness in each block; and a device 18 for determining
the category of a block.

The device 5 computes the average brightness in 12
sub-blocks of 4x8 picture elements, at the periphery of
10 each block, then computes the average brightness in 12
areas of 4x8 elements, according to the method previously
described and illustrated in Figures 7 and 8. The device
17 determines the minimum value from among the average
values computed by the device 16. The device 18 compares
15 this average value with the 7 fixed threshold values and
derives from this a binary word whose value can vary
between 0 and 7 and which constitutes the category number
of the block, representing the difficulty of encoding and
of restoration of this block. The device 5 is controlled
20 by the sequencer 11 by means of links which are not
shown. The device 5 can be produced in the form of a
hard-wired logic circuit or in the form of microprocessor
and a program memory. In both cases, its embodiment is
within the scope of a person skilled in the art.

25   Figure 11 shows the block diagram of the brightness
encoding device 6. The device 7 has an entirely similar
block diagram. In this embodiment the device 6 com-
prises: a device 43 for computing a two-dimensional
cosine transformation over blocks of size 16x16. The
30 device 43 has an input connected to the input terminal 20
in order to successively receive the brightness values
corresponding to a picture block. The two-dimensional
transformation is computed in two stages corresponding to
two one-dimensional transformations, implementing the
35 known Beyong Gi Lee algorithm. The device 43 can be
embodied for example according to the description given
in the French Patent Application N° 2,581,463.

The encoding device 6 furthermore comprises means
enabling the computation in parallel of the transforma-
tion coefficients of a block of brightness values and the
differences between these values and the transformation
5   coefficients of the similar block in the previous frame.
It performs the operations of weighting, quantification
and encoding of the sequences of zeroes, in parallel on
the coefficients and on the differences of transformation
coefficients.

10   The transformation coefficients computed by the
device 43 are successively processed by a weighting
device 45, a quantification device 46; and a device for
encoding the sequences of zeroes 47. The latter has a
first output and a second output respectively supplying
15   encoded data and an indicator indicating the type of data
supplied, i.e.: the value of a transformation coefficient
or length of a sequence of zeroes. These two outputs are
respectively connected to two inputs of a memory 52 in-
tended for storing data and the corresponding indicators,
20   for a block of picture elements encoded according to the
intra-image encoding. The memory 52 has two data outputs
respectively connected to two inputs a_1 and a_2 of a multi-
plexer 51, in order to respectively supply it with a data
word and an indicator word.

25   The device 6 also comprises a subtracter 44 having
a first input connected to the output of the device 43
in order to receive the value of a transformation coef-
ficient and having a second input connected to an output
of a memory 42 storing the values of the transformation
30   coefficients of the similar block to the one being pro-
cessed, in the frame encoded immediately previously. The
subtracter 44 therefore computes the difference between a
transformation coefficient and the similar transformation
coefficient in the preceding frame. This difference is
35   then successively processed by a weighting device 48, a
quantification device 49, and a device 50 for encoding
sequences of zeroes. The device 50 has two outputs

respectively supplying an encoded datum constituted by
a difference of transformation coefficients or by a
length of a sequence of zeroes, and supplying an indi-
cator corresponding to this type of data.

5   These two outputs are respectively connected to two
data inputs of the block memory 53, intended for storing
data and corresponding indicators for a block of
picture elements encoded according to the inter-
picture encoding. The memory 53 has two data
10   outputs respectively connected to two imputs
b_1 and b_2 of the multiplexer 51 in order to supply
it with a data word and an indicator word respectively,
the latter constituting an instruction for controlling
the device 10.

15   The multiplexer 51 has a control input connected to
an output of a device 39 for selecting the type of encod-
ing. It also has two outputs respectively connected to
the output terminals 23 and 24 of the device 6 in order
to respectively supply an instruction and a data word con-
20   stituted by a transformation coefficient value or a trans-
formation coefficient difference value, or a length of a
sequence of zeroes value. Depending on the value of a
control signal supplied by the device 39, the multiplexer
51 connects the inputs a_1 and a_2 respectively to its two
25   outputs or connects the inputs b_1 and b_2 respectively to
its two outputs, depending on whether the encoding to be
performed is of the intra-picture type or of the inter-
picture type respectively.

       The weighting devices 45 and 48, and the quantifi-
30   cation devices 46 and 49 have control inputs connected
to the input terminal 21 of the device 6 in order for
each of them to receive a binary word respectively de-
fining the weighting coefficient and the quantification
coefficient applied to the transformation coefficients
35   and to the differences of transformation coefficients of
the brightness values. The input terminal 21 is also
connected to an input of a device 34 computing the

computing the inverse of the weighting coefficient and
the inverse of the quantification coefficient.

The device 6 furthermore comprises a device 31 for
decoding sequences of zeroes corresponding to the
5 transformation coefficients, this device 31 having two
inputs respectively connected to the two outputs of the
device 47, and having an output supplying either a non-
zero transformation coefficient supplied by the first
output of the device 47, or a sequence of zero values,
10 depending on the value of the indicator supplied by the
second output of the device 47. The zero or non-zero
transformation coefficient values supplied by the device
31 are then successively processed by an inverse quanti-
fication device 32 and by an inverse weighting device
15 33 and are then supplied to a first input of a multi-
plexer 34.

The device 6 furthermore comprises a device 35 for
decoding the sequences of zeroes corresponding to
differences of transformation coefficients, having two
20 inputs respectively connected to the first output and to
the second output of the device 50 for respectively re-
ceiving data, constituted by differences of transforma-
tion coefficient or lengths of sequences of zeroes, and
indicators indicating the type of these data. The device
25 35 transmits the non-zero transformation coefficient
differences without modifying them, and it supplies a
sequence of zero values in order to restore the sequences
of zero transformation coefficient differences. These
transformation coefficient difference values are supplied
30 by an output of the device 35 and are successively pro-
cessed by an inverse quantification device 36 and by
an inverse weighting device 37 and are then applied to
the second input of the multiplexer 34.

The inverse weighting devices 33 and 37, and the
35 inverse quantification devices 32 and 36 have control
inputs connected to an output of the device 30 in order
to respectively receive the inverse weighting coefficient

and the inverse quantification coefficient corresponding
to the brightness values of the block being processed,
which are computed by the device 30. The multiplexer 34
has an output which is connected either to its first in-
5 put or to its second input, depending on the value of a
binary signal applied to a control input which is con-
nected to the output of the encoding type selection device
39. The output of the multiplexer 34 is connected to a
data input of a memory 41 storing the values of the trans-
10 formation coefficients of all of the blocks of picture
elements of the frame having been processed immediately
previously.

A data output of the memory 41 is connected to a
data input of a memory 42 storing only the transformation
15 coefficients of the block in the previous frame which is
similar to the block of picture elements being processed.
The memories 41 and 42 have write and read control inputs
connected to outputs of the sequencer 11 by links
which are not shown. A data output of the memory 42 is
20 connected to the second input of the subtracter 44 in
order to supply it with the value of the transformation
coefficients of the similar block, in an order corres-
ponding to the order of transformation coefficients
computed by the device 43, this order for example being
25 the zigzag order shown in Figure 1. The memory 42 and
the memory 41 act as a digital delay line providing a
one-frame delay.

The device 6 furthermore comprises a device 38 for
computing the cost of intra-picture encoding and a device
30 40 for computing the cost of inter-picture encoding, for a
same block of picture elements. The device 38 has two
inputs respectively connected to the two outputs of the
device 47 and has an output connected to an input of the
device 39 for selecting the type of encoding. The device
35 40 has two inputs respectively connected to the two
outputs of the encoding device 50 and has an output
connected to another input of the device 39. The devices

38 and 40 compute a cost of encoding taking account of
the inter-block, intra-block and inter-picture sepa-
rators; and taking account of the Huffmann code words
used for encoding each transformation coefficient, each
5   difference of transformation coefficient, and each
sequence of zeroes. The selection device 39 therefore
simultaneously receives two binary words indicating the
cost of encoding by intra-picture encoding and by inter-
picture encoding.

10   The device 39 determines which is the lowest cost
and in principle selects the type of encoding corres-
ponding to this cost. But it can also impose an intra-
picture encoding. The device 39 has a first output
connected to the control inputs of the multiplexers 34
15   and 51 in order to control the inter-picture encoding
or the intra-picture encoding; and it has a second
output connected to the output terminal 22 in order to
supply the cost of encoding of the block. This cost is
used for computing the filling of the virtual buffer
20   memory.

In order to compare the encoding costs and for
imposing the intra-picture encoding in certain cases, the
device 39 can be constituted from a microprocessor and a
read only memory containing a program corresponding to
25   the implementation of this method.

The method of forcing comprises three criteria. A
first criterion consists: in computing the difference
between the cost of the intra-picture encoding and the cost
of inter-picture encoding; then in dividing this difference
30   by the cost of the inter-picture encoding; then in comparing
the result with a first variable threshold value. This
first threshold value is computed by counting the number
$N(i,j)$ of blocks having the coordinates (i,j) and having
been encoded by an inter-picture encoding since the last
35   time that a block of coordinates (i,j) was encoded by an
intra-image encoding; then in computing a function of
$N(i,j)$, divided by a constant. This function can be

$N^2(i,j)$, for example.

A second forcing criterion consists in comparing the number $N(i,j)$ with a second threshold value, N_0, which is fixed at 30 for example. The encoding is forced to be 5 an intra-picture encoding when $N(i,j)$ exceeds 30.

A third criterion, intended to stagger the forcing operations in time, consists in only allowing the forcing for blocks whose number, in the frame in question, is equal to a value N_1 modulo 4. The value N_1 is a whole 10 value varying from 0 to 3 and changing at each frame.

The production of this computing program for a microprocessor is within the capabilities of a person skilled in the art.

Figure 12 is the block diagram of an embodiment of a 15 picture decoder for the implementation of the method according to the invention. This example comprises: an input terminal 57 connected to a transmission channel; a Huffmann decoder 58; a set 59 of synchronization registers; a memory 60; means of decoding the brightness 20 80; means of decoding the colour difference signals 81; a device 64 for recovery of the channel frequency; a device 65 for detecting the inter-block separators; a device 66 for detecting the inter-picture separators; a device 67 for detecting the picture synchronization patterns; a 25 device 68 for detecting the line synchronization patterns; a clock 69 at the video signals frequency; a counter 70 of write addresses of the buffer memory; a counter 71 of the cost of a block; a memory 72 for storing the parameters of a block; a counter 73 of read addresses 30 of the buffer memory; a device 74 for computing the inverse quantification coefficient and the inverse weighting coef- ficient; a counter 90 of the initial filling; a device 91 for computing the filling of the buffer memory consti- tuted by the memory 60, the decoder 58, and the registers 35 59; a counter 92 of the number of bits received; a category decoder 93; a sequencer 94; a counter 95 of write addresses of the parameters memory; a counter 96 of the read addresses

of the parameters memory; and three output terminals,
83 to 85, respectively supplying a brightness value
Y, a red colour difference value DR, and a blue colour
difference value DB.

5   The device 67 for detecting the picture synchroniza-
tion patterns and the device 68 for detecting the line
synchronization patterns have inputs connected to the
input terminal 57 and have outputs respectively connected
to the two inputs of the clock 69. The clock 69 supplies

10   a clock signal HV which will determine the frequency of
the brightness values, and of the colour difference
values restored by the decoder.

       The sequencer 94 supplies control signals to all of
the components of the decoding device in synchronism with

15   the video clock signal. For purposes of simplification,
this block diagram shows only one type of video clock
signal, referenced HV, but there are in fact several
video clock signals having frequencies which are sub-
multiples of the sampling frequency of the brightness

20   signal. The production of these clock signals is within
the capabilities of a person skilled in the art.

       The device 64 for recovering the channel frequency
has an input connected to the input terminal 57 and has
an output supplying a clock signal HC corresponding to

25   the frequency of the bits transmitted on the channel.
This clock signal is applied in particular to a clock
input of the counter 71 counting the cost of a block in
order to count the number of bits corresponding to each
block received.

30   The Huffmann decoder 58 has an input, connected to a
transmission channel by the input terminal 57, for receiv-
ing a series of binary values at a constant frequency of
10Mb per second, this series being transmitted by an
encoding device such as described previously. It also

35   has a clock input receiving the clock signal HC, and a
synchronization input connected to a first output of the
inter-block separator detection device 65. The latter

supplies a signal which reinitializes the decoder
58 at the start of the transmission of the encoded data
of each block. The decoder 58 can only decode a code
word corresponding to an event if it has correctly
5   decoded the code word corresponding to the preceding
event. In the case of a transmission error, the Huffmann
decoder remains unsynchronized until the detection of the
next inter-block separator.

The device 65 has an input connected to the input
10   terminal 57 in order to receive the transmitted bits and
to (sic) an input connected to an output of the decoder
68 (sic) in order to receive a logic signal each time
that the decoder 58 has decoded an event.

The function of the device 65 is to recognize each
15   inter-block separator by means of the pattern
constituting the radical, and to check the absence of
transmission error by means of the two binary words which
follow the radical. For this purpose, it compares the
rank of the block, modulo 4, transmitted in the inter-
20   block separator, and the rank of the block counted
according to the number of previously received separa-
tors. Furthermore the device 65 checks the number of
code words received, i.e, the number of events in the
previous block, by comparing the transmitted value of the
25   sum of the rank of the block and the number of events,
modulo 4, with the sum computed from the number of
previously detected blocks and from the number of
previously detected events, modulo 4. An inter-block
separator is recognized as valid by the device 65 when it
30   is followed by two other inter-block separators checking
these two conditions.

When one of these three checks gives a nega-
tive result, a second output of the detection device
65 supplies a masking command constituted by a binary
35   word NBM indicating the number of blocks to be masked, to
a first input of the memory 72. The association of this
error detection and the process of masking incorrect

blocks enables incorrect transmissions to be corrected
in most cases.

In general, error correcting devices, adapted to the
type of channel, are respectively interposed between the
5   output terminal 19 of the encoding device and the input
terminal 57 of the decoding device. These devices are
conventional and are not shown in the figures. They
enable the correction of small packets of errors, by
means of a small redundancy of the transmitted bits. The
10   checks performed by the inter-block separator detection
device 65 enable the detection of the errors which
remain. The latter can be serious for the restored
picture because they can falsify not only the brightness
or the colours of a block but can affect the position of
15   the whole of the block if an inter-block separator is not
recognized. The checking of the rank of each inter-block
separator and the checking of the number of decoded
events enables a precise computation of the number NBM of
blocks to be masked and therefore enables them to be
20   masked and the restoration of an image having a much
better quality than if the blocks were restored in
inaccurate positions.

The first output of the device 65 is also connected
to a zero reset input of the counter 71 for counting the
25   cost of a block; to a clock input of the counter 95 of
write addresses of the memory 72; and to an input of the
sequencer 94 by means of a link which is not shown.

When an inter-block separator is valid, the binary
signal supplied by the first output of the device 65
30   reinitializes the Huffmann decoder 58, resets to zero the
counter 71 counting the cost of a block, increments the
counter 95 of write addresses by one unit, and initiates
the sequencer 94 such that it commands a writing, in the
memory 72, of the parameters of the block which is
35   recognized as valid. The parameters written into the
memory 72 are: the address, ADB, of writing the first
word of the encoded data of the block, into the memory

60; the cost of this block, CB, i.e. the number of bits
between the two inter-block separators enclosing these
data; and the value of MBN which is equal to the number
of blocks to be possibly masked, this number being zero
5   when there is no block to be masked. These three
parameters are respectively supplied by the output of
the counter 70 write addresses of the buffer memory;
the output of the counter 71 counting the cost of a
block; and by the third output of the inter-block
10 separator detection device 65. These three outputs are
respectively connected to three data inputs of the
memory 72. The latter has a first, second and third
data output for respectively restoring the values of
these three parameters. It also has read and write
15 control inputs connected to outputs of the sequencer 94
by links which are not shown.

       When an inter-block separator is recognized as
valid, the sequencer 94 controls a writing into the
memory 72 for storing the parameters of the block which
20 follows this separator. The counter 95 of write
addresses has an output connected to a write address
input of the memory 72 in order to supply it with a
write address for the parameters each time that an
inter-block separator is validated. When one or more
25 inter-block separators are not recognized as valid, a
single set of parameters is written into the memory 72
for the data of several blocks, as everything happens
as though the data corresponded to a single block.
These data are stored in the buffer memory 60 even if
30 they are incorrect, and they are read from the memory
60, but they are not used for restoring a picture. The
counter 95 also has a zero reset input connected to the
output of the picture synchronization detection device
67 in order to be reset to zero at the start of each
35 picture.

       The output of the counter 70 of write addresses
is also connected to a write address input of the buffer

memory 60. An input for loading the counter of read
addresses, 73, is connected to the first data output of
the memory 72 in order to receive a start of block
address, ADB; and has an output connected to a read
5   address input of the buffer memory 60. The counter 70
has a clock input receiving the video clock signal HV,
and has a zero reset input connected to the output of
the device 67. The output of the device 67 is also
connected to a zero reset input of the counter 73 of
10   read addresses of the buffer memory. The counter 73 has
a clock input connected to an output of the sequencer
94 by a link which is not shown.

The second output of the memory 72 is connected to
an input of the device 91 for computing the filling of
15   the buffer memory in order to supply it with the cost of
a block, CB. The third output of the memory 72 is
connected to an input of the sequencer 94 and to an input
terminal 86 of the means 80 and 81 for supplying them
with the value of the number of blocks to be masked,
20   NBM.

The Huffmann decoder has a first output and a second
output respectively connected to two inputs of registers
59 which are called synchronization registers as they
enable the synchronization of the encoded data with the
25   video clock HV, while the Huffmann decoder 58 operates at
the channel clock frequency HC. The decoder 58 has a
third output supplying an encoding selection binary
signal: inter-picture encoding or intra-picture encoding,
to an input terminal 75 of the means 80 and 81. Two
30   outputs of the synchronization registers 59 are
respectively connected to two data inputs of the buffer
memory 60, respectively corresponding to encoded data
and to a binary instruction word indicating the type
of encoded data. The buffer memory 60 has a first
35   output and a second output respectively connected to
input terminals 77 and 76 of the means 80 and 81 in
order to supply them respectively with encoded data

and a binary instruction word.

The memory 60 also has a write clock input and a read clock input respectively connected to two outputs of the sequencer 94 by links which are not shown. When
5 an inter-block separator has been recognized as valid, the sequencer 94 commands the writing into the memory 60, of the encoded data corresponding to at least one block, at a series of addresses supplied by the counter 70, following the start address of the block ADB, which
10 is the only one stored in the memory 72.

For reading the encoded data stored in the memory 60, the sequencer 94 commands, for each block or group of blocks (if an error has been detected):

- a reading, from the memory 72, of the address ADB
15 corresponding to the start of the block;

- a loading of this address into the counter of read addresses 73;

- a reading at the address ADB, from the buffer memory 60, the address ADB having been supplied to the
20 read address input by the counter 73;

- a series of incrementations of the content of the counter 73;

- a series of readings, from the buffer memory 60, at addresses supplied by the counter 73.

25 As the memory 60 is placed downstream of the Huffmann decoder 58, everything occurs as if, instead of the decoder 58 and the memory 60, there were a buffer memory storing in series the binary data transmitted by the channel and restoring them in series. The computing
30 device 91 in fact computes the filling of this buffer memory, which is not related mathematically to the filling of the memory 60 as the latter contains binary words supplied by the Huffmann decoder. The filling of the buffer memory is equal to the quantity of binary
35 information, in the form of Huffmann codes, which remains to be decoded at the instant in question. The capacity of the memory 60 is identical to the capacity of the

memory 9 of the encoding device and is sufficient in all
cases.   In this example it is 32K words, each word being
constituted by a datum and an instruction.

     The device 74 for computing the quantification

5   coefficient and the weighting coefficient has two outputs
respectively connected to input terminals 78 and 79 of
the means 80 and 81, and has two inputs respectively
connected to an output of the computing device 91 and to
an output of the category decoder 93.   The computing

10 device 91 has a first input connected to the second data
output of the memory 72, supplying a binary word CB which
is the cost of encoding a block; a second input connected
to an output of the initial filling counter 90, supplying
a value OCI; a third input connected to an output of

15 the counter 72, supplying the number of bits received
NCANAL; and a fourth input, a zero reset input, connected
to an output of the picture synchronization detection
device 67.

     The initial filling counter, 90, has a clock input

20 receiving the video clock signal HV; a stop input
connected to the output the inter-picture separator
detection device 66; and a zero reset input connected to
the output of the picture synchronization pattern
detection device 67.   The counter 90 counts the number

25 of bits supplied by the channel to the buffer memory,
between the instant at which a picture synchronization
pattern is detected and the instant at which an inter-
picture separator is detected.   The result of this
count constitutes the value of the initial filling OCI

30 of the buffer memory, at the start of the each
picture.

     The counter 92 of the number of received bits has an
input connected to the input terminal 57 and an input
connected to an output of the sequencer 94.   The counter

35 92 measures the exact number of bits received by the
buffer memory since the start of a block, this number
not being known in advance in an accurate way as the

channel is asynchronous. The counter 92 is reset to zero
by a signal supplied by the sequencer 94, in principle at
the start of the reception of each block, but the
sequencer 94 skips one or more zero resets when the
5   binary word NBM is not zero, i.e. when there is at least
one block to be masked. For example, if there are two
blocks to be masked, the sequencer 94 only commands a
zero reset of the counter 92 at the end of the second
masked block.
10   The category decoder 93 has an input connected to
the input terminal 57 for decoding a binary word
indicating a category and located just after each inter-
block separator. It supplies this binary word to the
computing device 74 which takes it into account for
15   computing the quantification coefficient and the inverse
weighting coefficient in the same way as the device for
computing the quantification and weighting coefficients
in the previously described encoding device.
The device 74 for computing the inverse quanti-
20   fication coefficient and the inverse weighting coef-
ficient operate in a similar way to the device 30 com-
puting the quantification coefficient and the weighting
coefficient, but in addition it performs the
computation of the inverse of the quantification
25   coefficient and the inverse of the weighting
coefficient obtained by the formulae (3) to (8).
In these formulae the filling of the buffer memory
of the encoding device is replaced by a value which is
equal to a constant less the filling of the buffer
30   memory of the decoding device. In fact, the sum of the
filling of these two buffer memories is equal to a
constant when the regulation is correctly operating in
the encoding device and the decoding device, the
consequence of this regulation being that each encoded
35   datum undergoes a constant delay between the time at
which it enters into the buffer memory of the encoding
device and the time at which it leaves the buffer

memory of the decoding device, since the data rate of
the channel is constant. This delay corresponds to the
constant value of the sum of the two fillings.

This constant is determined by measuring the
5   initial filling OCI of the buffer memory of the
decoding device, by means of the initial filling
counter 90, which measures the number of bits entering
into the device 58 between the time at which the device
67 detects the picture synchronization pattern, which
10 is transmitted independently from the flow of encoded
data, and the time at which the device 66 detects the
presence of an inter-picture separator in the encoded
data arriving at the input of the device 58. The
maintenance of the complementary nature of the filling
15 of the two buffer memories enables the inverse
quantification coefficient and the inverse weighting
coefficient to be computed exactly in the decoder. No
information representing the filling of the buffer
memory is sent in clear on the transmission channel and
20 consequently this information is not disturbed by the
errors.

Figure 13 shows the more detailed block diagram of
the brigtness decoding means 80. The means 81 have a
similar block diagram and are used alternately for
25 decoding the red colour difference signals and blue
colour difference signals. The means 80 comprise: an
inverse quantification device 101; an inverse weighting
device 102; three multiplexers 103 to 105, each having
two inputs and one output; a memory 106 storing a block
30 of transformation coefficients; an adder 107; a sequencer
108; a register 109 for storing a similar coefficient; a
memory 110 for storing the blocks of similar coefficients
in the frame preceding the current frame; a device 111
for decoding the sequences of zeroes; a frame memory 112;
35 and a device 113 for computing the two-dimensional
inverse cosine transforms.

The device 101 has a data input connected to the

input terminal 77 which receives encoded data supplied by the buffer memory 60, and has a control input connected to the input terminal 78 which receives the value of an inverse quantification coefficient computed by the device

5   74. An output of the device 101 is connected to an input of the device 102. The latter also has an input connected to the input terminal 79 in order to receive the value of an inverse weighting coefficient computed by the device 74, and has an output connected to a first

10   input of the multiplexer 103. The multiplexer 103 has a second input continuously receiving a zero value, and has an output which is connected either to the first input or to the second input depending on the value of a binary signal applied to a control input, connected to an output

15   of the device 111.

     The device 111 decodes the sequences of zeroes from the data and from an instruction, applied respectively to a first input and to a second input which are respectively connected to the input terminal 77 and to

20   the input terminal 76 of the means 80. The output of the multiplexer 103 therefore supplies the value of a coefficient or a difference of transformation coefficient. It is connected to a first input of the multiplexer 104 and to a first input of the adder 107. A

25   second input of the adder 107 is connected to an output of the register 109 which supplies it with the value of the transformation coefficient similar to the coefficient being decoded and occurring in the picture preceding the picture being decoded.

30   The output of the adder 107 therefore supplies the value of a transformation coefficient when its first input receives the value of a difference of transformation coefficient. This output is connected to the second input of the multiplexer 104. The multi-

35   plexer 104 has a control input connected to the input terminal 75 in order to receive the value of a control bit selecting an inter-picture decoding or an intra-

picture decoding, and it has an output connected to a
first input of the multiplexer 105. A second input of
the multiplexer 105 is connected to the output of the
register 109 in order to receive the value of the
5 coefficient similar to the coefficient being
decoded. A control input of the multiplexer 105 is
connected to an output of the sequencer 108 in order
to possibly receive a masking control signal. When
this masking signal is applied to the multiplexer 105,
10 the latter transmits the value of the similar coef-
ficient supplied by the register 109 instead of trans-
mitting the value of the transformation coefficient
supplied by the multiplexer 104.

The output of the multiplexer 105 is connected to a
15 data input of the memory 106. The memory 106 has write
and read control inputs respectively connected to the
outputs of the sequencer 108, the latter commanding the
memory 106 to store all the transformation coefficients
of a block before commanding the inverse cosine
20 transformation of these coefficients. The sequencer 108
has an input receiving the video clock signal HV, an
input connected to the input terminal 76 in order to
receive an instruction depending on the type of data to
be decoded and an input connected to the input terminal
25 86 in order to receive the value NBM of the number of
blocks to be masked. If NBM = 0 the sequencer 108 does
not command the masking. If NBM is other than 0, the
sequencer 108 commands the masking of the number of
indicated blocks.

30 The memory 110 has a data input connected to a data
output of the memory 106 in order to store all of the
blocks of transformation coefficients resulting from
the decoding of a frame in order to be able to supply
the coefficients similar to the transformation
35 coefficients of the following frame. The memory 110 has
a data output connected to a data input of the register
109, and has read and write control inputs connected to

the outputs of the sequencer 108.

The data output of the memory 106 is also connected
to an input of the computing device 113. The latter has
a zero reset input connected to an output of the
5 sequencer 108, and has an output connected to a data
input of the picture memory 112. The frame memory 112
has a read and write control input connected to outputs
of the sequencer 108 and has a data output connected to
the output terminal 83 of the decoder, in order to supply
10 a series of brightness values Y. The frame memory 112
has the function of restoring the series of brightness
values in the conventional scanning order of a frame
while the computing device 113 supplies the decoded
brightness values in the order of division of the blocks
15 in the frame. The embodiment of the computing device 113
for performing inverse cosine transformations is
conventional. It can be embodied according to the
description in the French Patent Application No.
2,581,463.

20 The scope of the invention is not limited to the
examples of embodiment described above and numerous
variant embodiments are within the capabilities of a
person skilled in the art.